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U.S. Army Corps of Engineers
Washington, DC 20314-1000

CEMP-ET

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20 October 1989

Engineering and Design
TRANSFORMER APPLICATION GUIDANCE

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Engineer Technical
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Engineering and Design
TRANSFORMER APPLICATION GUIDANCE

1. Purpose. This letter provides advance criteria for design application of transformers, prior to update of current guide specifications.

2. Applicability. This letter applies to all HQUSACE/OCE elements and all field operating activities (FOA) having Army military design and construction responsibility.

3. Action to be Taken. Pending update and publication of permanent media guidance, the criteria provided in Enclosure 1 will be used as an interim design guidance for all transformer applications.

4. Implementation. This letter will have special application as defined in paragraph 6c, ER 1110-345-100.

FOR THE DIRECTOR OF MILITARY PROGRAMS:



Encl

HERBERT H. KENNON
Chief, Engineering Division
Directorate of Military Programs

TRANSFORMER APPLICATION ADVISORY

1. **GENERAL.** The criteria, standards, and application guidance for transformers contained in this advisory will be incorporated in "TECHNICAL MANUALS" and "CORPS OF ENGINEERS GUIDE SPECIFICATIONS." These changes are a direct result of a multi-service meeting on transformer dielectrics and their hazards.

2. **PURPOSE.** This advisory provides current (criteria, standards, practices, and policy) requirements for the application of transformer into MCA projects.

3. **TYPE OF PROJECTS.**

a. **New Facilities.**

(1) For new facilities, the following relatively nonhazardous transformer dielectric materials are permitted on MCA projects:

- (a) Mineral Oil.
- (b) High Fire-Point:
 - (b.1) High-Molecular-weight hydrocarbon.
 - (b.2) Silicon.
- (c) Dry Type:
 - (c.1) Open dry.
 - (c.2) Closed dry.
 - (c.3) Bisphenol Epoxy dry.

(2) The application guidance for the three transformer types (Mineral Oil, High Fire-Point and Dry) are as follows:

- (a) Mineral Oil Dielectric Transformers:

INDOOR APPLICATION

The indoor application of mineral oil dielectric filled transformer will comply with the "National Fire Protection Code," "National Electrical Code," MIL-HDBK-1008, "Fire Protection For Facilities Engineering Design and Construction" and the "National Electrical Safety Code."

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Transformer vaults will be located on the exterior wall of the building, vented to the outside and accessible only from outside the building under normal design conditions.

Air intake fan and louvers of HVAC systems will be interlocked with the smoke and rate-of-rise detector in the transformer vault and/or vault rooms. The smoke and rate-of-rise detectors will shut down the HVAC air intake if a fire occurred in the transformer vault and/or vault rooms. This is not necessary if the HVAC intake is located on the roof or the opposite side of the building. A sign will be posted on the access doors to a transformer vault which indicates the appropriate firefighting equipment and procedures.

OUTDOOR APPLICATION

The outdoor application of mineral oil filled transformers will comply with MIL-HDBK-1008, "Fire Protection For Facilities Engineering Design and Construction," "National Electrical Safety Code" (ANSI-C2), and pertinent EPA regulations.

Mineral oil transformers. will be sited to preclude any reasonable chance that products of combustion from a transformer fire will be drawned into the HVAC air intake of adjacent building.

(b) High Fire-Point Transformer Dielectrics:

INDOOR APPLICATION

The indoor application of high-fire-point dielectric filled transformer will comply with the "National Fire Protection Code," National Electrical Code," MIL-HDBK-1008, "Fire Protection For Facilities Engineering Design and Construction" and the "National Electrical Safety Code."

Transformer vaults will be located on the exterior wall of the building, vented to the outside and accessible only from outside the building under normal design conditions.

Air intake fan and louvers of HVAC systems will be interlocked with the smoke and rate-of-rise detector in the transformer vault and/or vault rooms. The smoke and rate-of-rise detectors will shut down the HVAC air intake if a fire occurred in the transformer vault and/or vault rooms. This is not necessary if the HVAC intake is located on the roof or the opposite side of the building. A sign will be posted on the access doors to a transformer vault which indicates the appropriate firefighting equipment and procedures.

OUTDOOR APPLICATION

The outdoor application of high-fire-point filled transformers will comply with MIL-HDBK-1008, "Fire Protection For Facilities Engineering Design and Construction," "National Electrical Safety Code" (ANSI-C2), and pertinent EPA regulations.

High-fire-point transformers will be sited to preclude any reasonable chance that products of combustion from a transformer fire will be drawned into the HVAC air intake of adjacent building.

(c) Dry Type Transformer Dielectrics:

INDOOR APPLICATION

Dry type transformers are available in four types:

1. Open Dry.
2. Closed Dry.
3. Sealed Dry (dry nitrogen filled)
4. Cast Coil (primary and secondary vacuum casted)
Bisphenol Epoxy.

The indoor application of dry type dielectric transformer will comply with the "National Fire Protection Code," "National Electrical Code," MIL-HDBK-1008, "Fire Protection For Facilities Engineering Design and Construction" and the "National Electrical Safety Code" where applicable.

The open dry type transformer will be installed in a controlled environment (the environmental air must be filtered and humidity controlled in a room or vault as required by the manufacturer)

The sealed or closed dry type transformers will be installed in a cleaned ventilated room/vault.

The cast coil type transformer will be used in a clean ventilated environment (room/vault) or routine cleaning will be required.

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Dry type transformers will be sited to preclude any reasonable chance that products of combustion from a transformer fire will be drawned into the buildings HVAC system.

OUTDOOR APPLICATION

Open dry type transformers will not be used outdoor.

Closed dry type transformers may be used outdoors if housed in approved enclosure.

Sealed dry type transformers may be used outdoor if sheltered from the elements.

Cast coil type transformers may be used outdoor with approved housing/enclosure.

The outdoor application of dry type transformers will comply with MIL-HDBK-1008, "Fire Protection For Facilities Engineering Design and "National Electrical Safety Code" (ANSI-C2) , and pertinent EPA regulations.

Dry type transformers will be sited to preclude any reasonable chance that products of combustion from a transformer fire will be drawned into the HVAC air intake of adjacent building.

b. Rehabilitation of Existing Facilities.

(1) For facilities, where the dielectric of existing indoor transformers and capacitors are EPA and/or NIOSH listed as a hazardous chemical [Askarel (PCB) Tetrachloroethylene, and Freon 113] the following will be observed:

(a) The dielectric will be verified.

(b) A cost-risk analysis for each structure will be made.

(c) Where the cost-risk analysis requires elimination of the risk, retrofitting of transformers and capacitors will be specified in-lieu-of retrofilling.

(d) For those facilities which are mandatory for national security, the cost-risk analysis indicates elimination of the risk.

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(e) The contract specifications will mandate that the contractor or his sub is or will be certified in the current EPA regulations for handling, storage, transportation, disposal, clean-up, safety and health hazards.

(2) Application guidance for retrofits will follow the guidance covered under a, "New Facilities."

NOTE:

Paragraph 3.3, "Liquid Insulated Transformers" from MIL-HDBK-1008 is incorporated as pages 6, 7, 8, and 9 for your guidance.

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b) Electrical equipment in pulverizer areas should be suitable for Class II (NEC designation) hazardous areas. In normally clean areas, electrical equipment should be dust-tight (NEMA Type 5).

3.2 Power Generating and Utilization Equipment

3.2.1 General. In general, all electrical installations shall conform to NFPA 70, National Electrical Code. Specific details on the hazards of internal combustion engines, gas turbines, generators and transformers are covered in the NFPA, Fire Protection Handbook, and the FM, Loss Prevention Data Sheets.

3.2.2 Stationary Combustion Engines and Gas Turbines. NFPA 37, Stationary Combustion Engines and Gas Turbines, shall be followed for internal combustion engine and gas turbine and generator installations. Unless located in sprinklered areas the following shall apply:

a) Isolated installations may be protected with a self-contained pressurized sprinkler or water spray system with adequate supply to maintain a density of 0.2 gpm/ft² (8 l/min/m²) for 2,000 ft² (184 in²) for 40 minutes.

b) Where a turbine is installed as an individual unit in an enclosure, a carbon dioxide system is acceptable as primary protection in accordance with the following criteria for acceptance.

(1) For turbine compartments, the rate of discharge shall be such that a 34 percent concentration of carbon dioxide is attained within 1 minute after actuation and a 30 percent concentration shall be maintained throughout the deceleration period and until all metal surfaces likely to reignite oil are cooled to below the autoignition temperature of the oil 400-500° F (204-260° C).

(2) For accessory compartment., to extinguish fires in electrical equipment and oil, a concentration of 50 percent of carbon dioxide shall be obtained within 1 minute after actuation. No less than 30 percent concentration shall be maintained for the following 10 minutes.

(3) Where it can be established that fire temperatures will be below the decomposition temperature of Halon 1301 (under 900° F [482° C]), Halon 1301 shall be acceptable as an extinguishing system with provisions that the Halon discharge is sufficient to maintain a minimum design concentration of 5 percent throughout the deceleration period of the turbine.

c) Large individual units over 25,000 bp (18.63 MW) shall have backup protection of automatic sprinklers.

d) Emergency generators shall be protected by a local application of carbon dioxide.

3.3 Liquid-Insulated Transformers

3.3.1 Oil-Insulated Transformers. Fire protection equipment needed for outdoor transformers depends on their size and importance. Table 7 provides

Table 7
Fire Protection for Outdoor Oil-Insulated Transformers

SIZE (EACH TRANSFORMER)	NUMBER	PROTECTION
Under 9,999 ~VA 10,000 - 99,999 kVA ¹ 10,000 - 99,999 kVA ¹	One or more One only More than one	Portable Extinguishers Hydrant Protection a. Provide a 25-ft. (S m) minimum clear space between units, or b. Noncombustible barriers between units, or c. Fixed automatic waterspray 100,000 kVA and above. One or more fixed automatic water sprays
10,000 kVA and above	One or more	Fixed automatic water spray

¹ Where there are mission-essential bus structures exposed to a possible transformer oil fire, or electric service or production could be interrupted for an extended period, a fixed automatic water spray system shall be provided to minimize the physical damage from fire and reduce the downtime for repairs.

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fire protection requirements for single-phase or polyphase outdoor transformers.

Buildings located 25 ft (8 m) or more from an oil-cooled transformer do not require fire exposure protection. Buildings within 25 ft (8 m) of a transformer require exposure protection by one of the following method.:

a) Protect transformers with a permanently piped water spray system.

b) Where transformers expose only one building of masonry or concrete construction, the following safeguards shall be provided where applicable:

(1) There shall be no window openings in first story walls within a horizontal distance of 10 ft (3 m) from the transformers. Existing window opening. shall be closed using brick or concrete block.

(2) Window openings in the first story beyond 10 ft (3 m) and up to 25 ft (8 m) horizontally from the transformers shall be protected, using either wired-glass in steel sash or glass block.

(3) Window openings in second and third story walls directly above the transformers shall be protected using either wired-glass in steel sash or glass block.

(4) Overhanging eaves, where they exist, shall be fireproof.

c) Where transformers must expose a building having walls other than masonry or concrete, the following safeguards shall be taken:

(1) Provide a masonry or concrete barrier between building and transformers, with wing walls at each end of the barrier. The barrier shall extend at least 1 ft (300) above the top of transformer bushings and pressure-relief vents. The wing walls shall be of the same height and shall extend horizontally 2 to 3 ft (600 to 900 mm) beyond the transformers, including any radiators and tap-changer enclosures. At multistory buildings, provide a fire-resistive roof on this three-sided transformer enclosure.

d) Where transformers expose more than one building, such as transformers located in courts or angles between buildings or where yard space is limited, they shall be enclosed in a suitable fire-resistant vault and protected as shown in Table 8.

e) Where transformers are located on or above noncombustible roofs, suitable curbed and drained concrete mats or welded steel pans shall be underneath units and located so as not to expose roof structures. Oil-filled transformers shall not be installed on combustible roofs.

f) Oil-insulated transformers installed indoors shall be located in fire resistive vaults except for indoor transformer installations exempted by NFPA 70, National Electrical Code. Fire protection shall be provided in accordance with Table 8. Requirements apply to single-phase or polyphase lighting or power transformers.

Table 8
Protection for Oil-Insulated Transformers in Fire-Resistive Vaults

SIZE (EACH TRANSFORMER)	NUMBER	FIRE PROTECTION
60,000 kVA and below	One or more, not exceeding 60,000 kVA total	Hydrant Protection
60,000 kVA and below	More than one, exceeding 50,000 kVA total	Automatic sprinkler, water — spray, or carbon dioxide system
Over 50,000 kVA	One or more	Automatic sprinkler, water — spray, or carbon dioxide system

3.3.2 Less Flammable, Liquid-Insulated Transformers. Transformers insulated with less flammable liquids (fire point of not less than 572° F (300 C), as defined by ASTM D-92-72) shall be permitted to be installed without a vault in Type I and Type II (see Table 1) buildings in areas in which no combustible materials are stored, there is a liquid confinement area, and the installation complies with all restrictions provided for in the listing of the liquid. Such indoor installations not meeting the requirements of the liquid listing, or installed in other than Type I or Type II buildings, or in areas where combustible materials are stored shall (1) be provided with an automatic fire extinguishing system and a liquid containment area, or (2) be installed in an approved vault.

Transformers installed indoors and rated over 35,000 volts shall be installed in a vault.

Transformers installed outdoors shall adhere to the same requirements for ordinary oil insulated transformers; and if they present no exposure hazard to important structures, they may be protected with fire hydrants.

Outdoor transformer installations which are isolated and which present no exposure hazard to important structures may be protected with hydrants.

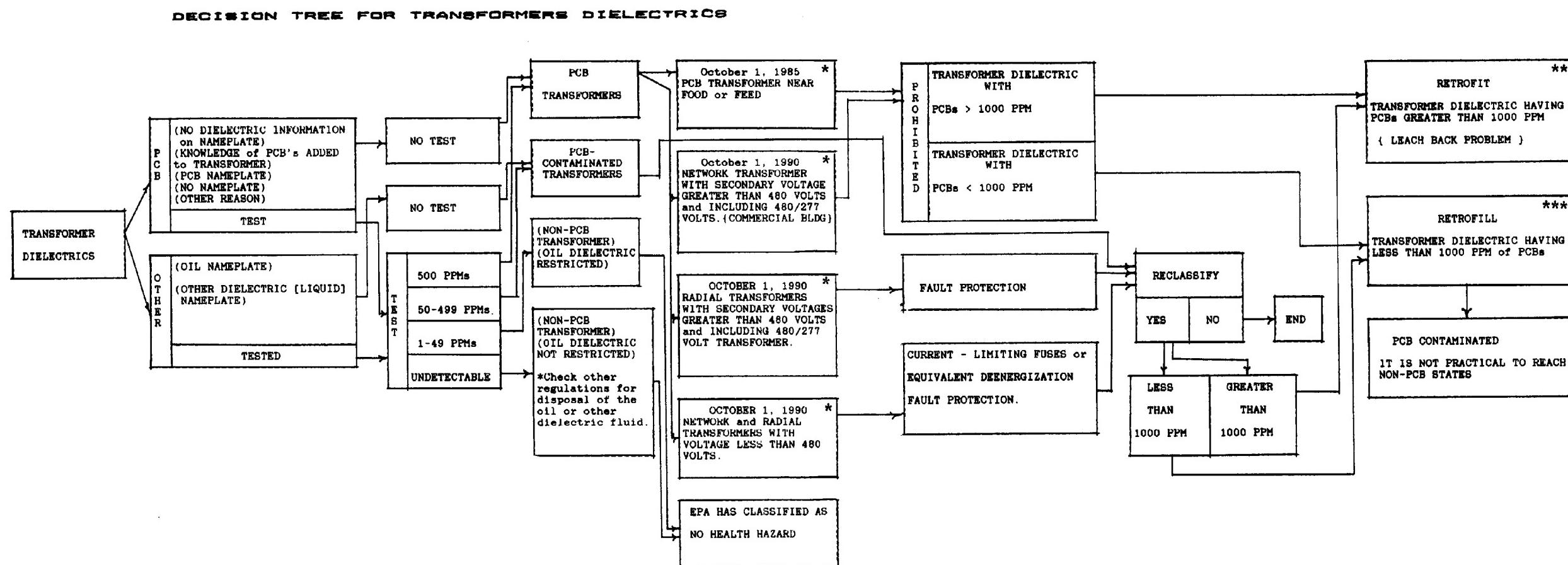
Consult FM Data Sheets for additional information.

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PCB and/or ELECTRICAL EQUIPMENT MANUFACTURERS
TRADE NAME LIST

<u>Manufacturer</u>	<u>Country</u>	<u>Trade Name</u>
Aerovox	US	Hyvol
Allis-Chalmers	US	Chlorextol
American Corp.	US	Asbestol
Axel Electronics	--	
Bayer	Germany	Clophen
Caffaro	Italy	Dk
Caffaro	Italy	Fenclor
Caffaro	Italy	Inclor
Capacitor Specialists	US	
Chemko	Czechoslovakia	
Cornell Dubilier	US	Dykanol
Dings Co.	US	
Electrical Utilities Corp.	US	Eucarel
Electro Engineering Works	US	
Electromagnetic Filter Co.	US	
Envirotech Buell	US	
Eriez Magnets	US	Pyranol
ESCO Mfg. Co.	US	Askarel
Farranti-Packard Ltd.	US	Askarel
General Electric	US	Pyranol
Geneva Industries	US	
H. K. Porter	US	
Helena Corp.	US	
Hevi-Duty Electric	--	Askarel
ITE Circuit Breaker	US	Non-Flammable Liq
Jard Corp.	US	Clorphen
Kanegafuchi	Japan	Kennechlor
Kuhiman Electric	US	Saf-T-Kuhl
McGraw Edison	US	Elemex
Maloney Electric	US	
Monsanto	UK and US	Aroclor
Monsanto	UK and Japan	Sanotherm FR
Monsanto	UK and Europe	Pyroclor
Monsanto	US	Therminol
Monsanto	US	Pydraul
Monsanto	US	Santovac 1 and 2
Niagara Transformer Corp.	US	Askarel , EEC-18
P. R. Mallory & Co.	US	Aroclor B
Power Zone Transformer	US	EEC-18
Prodelec	France	Phenoclor
Prodelec	France	Phyralene
R. C. Uptegraff	US	
R. F. Interronics	US	
Reliance Electric Co.	US	
Research-Cottrell	US	Askarel
Sangamo Electric	US	Diaclor
Sovol	USSR	
Sprague Electric Co.	US	Chlorinol
Standard. Transformer Corp.	US	
Stens Magnetics	US	
Tobe Deutschmann Labs.	US	
Universal Mfg. Corp.	US	Askarel
Van Tran Electric	US	
Wagner Electric	US	No-Flamol
Westinghouse Electric	US	Inerteen
York Electronics	US	
--	US	Nepolin
--	--	Apiolio
-	--	Kaneclor



NOTES:

- * These dates are EPA mandatory compliance dates.
- ** RETROFIT. Where possible the replacement transformer should be located outdoors.
- *** RETROFILL. Where the age and/or the condition of the transformer makes retrofit not practical, then retrofit.

DIELECTRIC HEALTH ADVISORY

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	A UNIVOLT 60 AND M61 MINERAL OIL	RTEMP	GE SFT-50 SILICON	BISPHENOL A ^a EPOXY	FREON 113 (1,1,2 TRICHLORO- 1,2,2-TRIFLUORETHANE	SULFUR HEXAFLUORIDE
HEALTH EFFECTS	Low toxicity	Low toxicity	Low toxicity	Low toxicity	Moderately toxic, not recommended for use	
TARGET ORGANS	Lungs, skin	Lungs, skin	Not well documented	-	Central nervous system (CNS) and heart	Central Nervous System
ACUTE EFFECTS	Inhalation-lipid pneumonia Dermal-contact dermatitis, folliculitis, oil acne, lipid granuloma, melanosis, seborrheic dermatitis, eczematous dermatitis. May cause eye irritation if contact occurs	Inhalation-lipid pneumonia Dermal-contact dermatitis, folliculitis, oil acne, lipid granuloma, melanosis, seborrheic dermatitis, eczematous dermatitis. May cause eye irritation if contact occurs	Mildly irritating to eyes	-	Anesthetic and asphyxiant	Simple asphyxiant, however, it can contain various quantities of low sulfur fluorides, some of which are toxic, chemically reactive and corrosive
CHRONIC EFFECTS	Not well documented	Possibility of hypersensitivity	Not well documented	-	CNS-interference with psychological and psychomotor functions, skin defatting and possible dermatitis	Chronic studies not considered necessary
1.2 SPECIAL CHARACTERISTICS	Contains an oxidation inhibitor, 2,6 diteriary butyl para- cresol-mild to moderate skin irritant, severe eye irritant high oral doses have reproductive and developmental effects in animal studies	Contains butylated hydroxytoluene-severe eye irritant high oral doses have reproductive and developmental effects in animal studies	-	-	Heart-sensitization	
EXPOSURE LIMITS	0.1 mg/m ³ OSHA - PEL ACGIH - TLV OTHER	5mg/m ³ 5mg/m ³ STEL 10mg/m ³	5mg/m ³ 5mg/m ³	None	Insufficient information	1000ppm 1000ppm STEL 1250ppm 1000ppm STEL 1250ppm

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A (cont.)	UNIVOLT 60 AND N61 MINERAL OIL	RTEMP	GE SF91-50 SILICON	BISPHENOL A EPOXY	FREON 113 (1,1,2 TRICHLORO- 1,2,2-TRIFLUOROETHANE	SULFUR HEXAFLUORIDE
MEDICAL SURVEILLANCE	Medical and work histories, physical examinations with special attention to respiratory system to include PFT and baseline chest x-ray, dermatologic system and eyes; no laboratory examination necessary	Medical and work histories, physical examination with special attention to respiratory system to include PFT and baseline chest x-ray, dermatologic system and eyes; no laboratory examination necessary	None recommended	Medical & work hist-medical & work histories ories, physical examinations with special attention to cardiovascular system to include echocardiogram, dermatologic system, ear, nose, throat, eyes and central nervous system; no laboratory examination necessary	None recommended	None recommended
PERSONAL PROTECTIVE EQUIPMENT					Respiratory protection not required unless exposure limits are exceeded. Skin contact-clothing made of chlorinated polyethylene (CPE) or flame retardant urethane (FRU). Eye contact-goggles or face shield	Respiratory protection not required unless exposure limits are exceeded. Skin contact-clothing made of Nitrile or Neoprene. Eye contact-goggles or face shield

B STORAGE REQUIREMENTS	UNIVOLT 60 and N61 MINERAL OIL	RTEMP SILICON	GE SF97-50 SILICON	BISPHENOL A EPOXY	FREON 113 (1,1,2 TRICHLORO- 1,2,2-TRIFLUOROETHANE	SULFUR HEXAFLUORIDE
INCOMPATIBILITIES	Store away from strong oxidizing agents, heat and open flames.	Store away from strong oxidizing agents, heat and open flames.	Store in cool, dry area in sealed containers away from strong oxidizers such as ozone, nitric acid, peroxide, concentrated oxygen and elementary chlorine.	Insufficient information	Store away from active metals (sodium, potassium, barium and calcium) and finely divided aluminum, magnesium, zinc and beryllium	Store in a cool, dry, well ventilated area out of sunlight. Contact with disilane causes explosions. Also reacts with molten sodium, but is unreactive with water, ammonia, hydrochloric acid, and alkali hydroxides.
VENTILATION	Well ventilated areas	Well ventilated areas	Well ventilated areas	Well ventilated areas	Well ventilated areas	Well ventilated areas
SPECIAL CHARACTERISTICS				Contact with soil and water can cause polymerization to moisture and to low molecular weight species.	Resin is susceptible to degradation due to moisture and temperature extremes in outdoor exposures. Insufficient information received to determine safe storage.	One of the heaviest gases known, at 5 times the density of air

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C DISPOSAL REQUIREMENTS	UNIVOLT 60 AND N61 MINERAL OIL	RTEMP	GE SF97-50 SILICON	BISPHENOL A EPOXY	FREON 113 (1,1,2-TRICHLORO-1,1,2- TRIFLUOROETHANE	SULFUR HEXAFLUORIDE
METHODS	Containerizing and labeling; material is generally not managed as a hazardous waste.	Coordinate turn in with local DRMO	Containerizing and labeling; material is generally not managed as a hazardous waste.	Insufficient information received to determine proper disposal procedures	When used in combination with mineral oil or other liquid dielectric fluids, it may solubilize into the fluid and constitute regulatory problems if ultimate disposition is by burning. If sulfur hexafluoride is not used in combination with a liquid dielectric fluid, disposal of the gaseous material would have to be evaluated as an atmospheric contaminant.	Manage and dispose of in accordance with strict regulations as cited below.

REGULATIONS

Regulated by USEPA
RCRA regulates waste containing Freon 113 as a spent halogenated solvent. Accidental discharge to the environment may require notification of the appropriate regulatory agency.

D ENVIRONMENTAL EMISSIONS	UNIVOLT 60 and N61 MINERAL OIL	RTEMP	GE SR97-50 SILICON	BISPIENOL A EPOXY	FREON 113 (1,1,2-TRICHLORO-1,2,2-TRIFLUORETHANE	SULFUR HEXAFLUORIDE
FIRE/EXPLOSION CONDITIONS	Moderate-fire hazard, combustion or decomposition products include: carbon monoxide, carbon dioxide, sulfur dioxide and aldehydes. Phenol or cresol may be released from combustion or decomposition of additives.	Moderate-fire hazard, combustion or decomposition products include: silicon dioxide, carbon monoxide, carbon dioxide and sulfur dioxide and aldehydes. Phenol or cresol may be released from combustion or decomposition of additives.	Combustion or decomposition products include: silicon dioxide, carbon monoxide, carbon dioxide and sulfur dioxide and aldehydes. Phenol or cresol may be released from combustion or decomposition of additives.	Marginally combustible, will burn if surrounded material burns. Combustion or decomposition products (released in small quantities) include: Toluene, phenol, ethylbenzene and benzene.	Non-flammable, however, at a temperature of 250°C, it decomposes to chlorine, fluorine, hydrochloric acid, hydrofluoric acid, phosphene and carbonyl fluoride.	Non-flammable, however, at temperatures ranging from 400° - 800°C or when allowed to contact an electric charge, decomposition to sulfur tetrafluoride and fluoride. Upon hydrolysis, sulfur decafluoride, hydrofluoric acid, sulfuryl fluoride and sulfur dioxide are formed.
SPECIAL FIREFIGHTING REQUIREMENTS	Firefighters required to wear full face piece self-contained breathing apparatus. Fire extinguishment may be accomplished thru the use of foam, carbon dioxide or dry chemical.	Firefighters required to wear full face piece self-contained breathing apparatus.	Firefighters required to wear full face piece self-contained breathing apparatus. Fire extinguishment may be accomplished thru the use of foam, carbon dioxide or dry chemical.	Firefighters required to wear full face piece self-contained breathing apparatus.	Firefighters required to wear full face piece self-contained breathing apparatus.	Firefighters required to wear full face piece self-contained breathing apparatus.